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ABSTRACT

The usage of the terms "diagnosis" and "prescription" in the fields of medicine and electronic troubleshooting is reviewed, and a common structure for diagnosis-prescription is proposed. The diagnosis-prescription decision sequence is outlined. Prescription-without-diagnosis and diagnosis-without-prescription in education is discussed. The implications of the diagnosis-prescription structure for instructional management and instructional program development are explored. A bibliography is appended. (SK)

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DIAGNOSIS-PRESCRIPTION IN THE CONTEXT OF INSTRUCTIONAL MANAGEMENT

The terms diagnosis and prescription appear frequently in descriptions of instructional strategies and in instructional management models. Diagnosis has been defined as "a description of student performance characteristics relevant to the instruction at hand" (Glaser and Nitko, 1971). Diagnosis is described as a process "...to gather information that may be helpful in making treatment decisions" (Della-Piana, 1968). Silver (1971) uses the term diagnosis in the context of interpreting individual performance on achievement tests and prescribing remedial assignments. Glaser and Nitko (1971) offer a second definition of diagnosis as a decision concerning teaching technique appropriate for an individual. Kriewall (1969) includes a broader class of decisions under the rubric "diagnosis and prescription," that being "to categorize learners into groups on the basis of their common requirement for instructional treatment." Bloom (Bloom, Hastings, and Madaus, 1971) accounts for some of these variations by distinguishing between two purposes of diagnosis, "...to place the student properly at the outset of instruction" and, "...to discover the underlying causes of deficiencies in student learning as instruction unfolds."

These references are but typical of the usage of the terms "diagnosis and prescription" in educational literature and, of necessity, have been quoted out of context. To clarify the usage of these terms, several questions can be posed. Are the concepts diagnosis and prescription inherently interdependent? Is diagnosis best considered to be a process, a decision, or both? How is diagnosis related to placement?

Background pertinent to these questions was sought in the usage of these terms in the fields of medicine and electronic troubleshooting. Educational usage typically has been influenced by medical rhetoric since the teacher-student relationship is often viewed as akin to the doctor-patient relationship. Engineering referents also appear worth consideration, particularly in an educational R&D context. Diagnostic decision models have been developed and tested in both medicine (Ginsberg and Offensend, 1968; Betaque and Gorry, 1971; and Croft, 1971) and electronic troubleshooting (Cremer and Teplitzky, 1969). Comparison of the meaning of the concepts in these fields to educational usage should facilitate the development of diagnostic procedures and algorithms in education. Problems found in implementing diagnostic decision models in medicine (Croft, 1971) may be particularly relevant to current attempts to assist teachers with computer-generated instructional prescriptions.

The Medical Diagnosis-Treatment Problem

Assume that a patient comes to a physician exhibiting or able to describe some set of symptoms. The set of feasible actions that might be taken immediately consists of diagnostic tests, treatments, or simply doing nothing. The purpose of diagnostic tests is to verify and quantify the described symptoms and to obtain further information concerning possible determinants of the symptoms in order to reduce uncertainty in the predicted effectiveness of each potential treatment. Assume that a diagnostic test cannot effect a cure, but may involve risk. There are instances where a doctor prescribes a treatment immediately without

diagnostic tests of any kind. This is done under several circumstances: (1) The observed symptoms or syndrome are an immediate threat to the patient's eventual recovery, (2) a particular low risk treatment usually alleviates the symptoms and whatever underlying causes exist and little risk is incurred in delaying diagnosis if, in fact, the patient's condition is not typical, and (3) the risk associated with potential diagnostic tests exceeds the risk of an incorrect treatment selection.

Prescription-without-diagnosis certainly occurs in medicine--and may be quite appropriate. The opposite case, diagnosis-without-prescription, is also common. The autopsy is a clear instance of diagnosis-without-prescription or treatment. Let us pursue this no further at this point; later the question will be raised whether there is an educational analogy to the autopsy.

The Electronic Troubleshooting Problem

The electronic troubleshooting problem is representative of diagnostic-decision problems dealing with electro-mechanical systems (televisions, automobiles, airplanes, etc.) that begin with some knowledge that the performance is malfunctional. The diagnostician has initial evidence that a non-normal state exists but lacks information about specific determinants.

Cremer and Teplitzky (1969) describe diagnosis in electronics as a multi-stage process:

Stage I: Test-selection strategy.

Stage II: Detection of symptom or noise from a received diagnostic datum.

Stage III: Recognition of malfunctions from symptom or noise patterns.

These stages are not entirely independent; the decision process may cycle through the three stages several times if the diagnostician should regard additional diagnostic tests necessary to reduce uncertainty in predicting malfunctions.

As with medical decisions, the course of action taken may be prescription and treatment without diagnosis. It may be more economical to replace components that have relatively short lifetimes (vacuum tubes, sparkplugs, etc.) than to engage in a diagnostic process. If such treatment-without-diagnosis fails to eliminate the symptoms, diagnosis may then be required.

Diagnosis-without-prescription is a less common but important occurrence. The detailed investigation into the cause of an airplane crash is a familiar example. No repair of the airplane is feasible or intended, but a diagnosis is conducted to learn why the crash occurred in the chance that a future accident may be prevented. The area of process control (Kriewall, 1969) is a less publicized case of diagnosis-without-treatment. Investigating the determinants of failure in an irrepairable system may result in improving the manufacturing process.

A Common Structure for Diagnosis-Prescription

The following structuring of the diagnosis-prescription problem, which emphasizes the similarities of decision processes in the three fields, is suggested. The problem comes to the attention of a decision maker by the evidencing of a syndrome--a readily apparent set of symptoms.

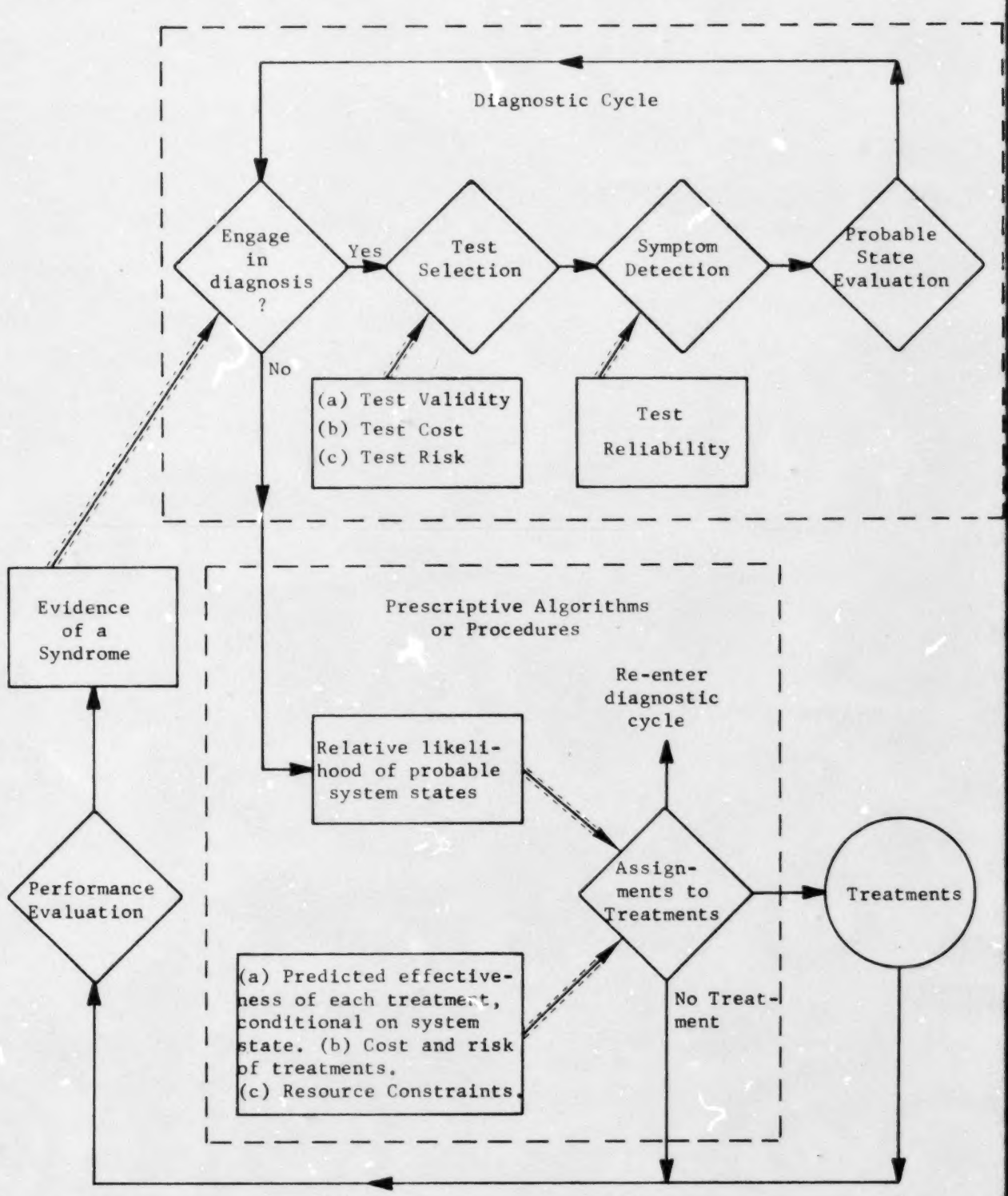
A symptom is defined as a measurable deviation of a system's behavior from what is considered to be normal (Ackoff, 1970). A treatment is any process to which the system may be assigned. A prescription is a decision to assign a system to a treatment.

It is assumed that each of the possible causes for the syndrome has identifying characteristics--a set of symptoms. Each possible cause (disease, malfunction, or disability) is treated as a state; the system is assumed to belong in one of the states. The syndrome is an indication that the actual state is an undesirable one; syndrome evidence may delimit the set of possible states, but, typically several states remain as probable causes.

Diagnosis is a cyclic, three-stage process of (1) test selection, (2) symptom detection, and (3) probable state evaluation. Tests are selected that are valid measures of symptoms which discriminate among the states currently considered as possible causes. Symptom detection is a decision that a symptom is or is not present; it may in some instances be expressed as a probability or a confidence measure. Probable state evaluation is a listing of states currently considered probable and an estimation of the relative likelihood of these states.

A prescriptive procedure or algorithm uses as input the current diagnostic information and considers the cost, risk (if any), and predicted effectiveness of each potential treatment. In addition to the set of potential treatments, one alternative is to engage in another cycle of the diagnostic process and a second is to do nothing. The entire process may be iterated if the selected treatments do not cause the system to assume a desirable state.

Diagnosis-Prescription Decision Sequence



The usage of the term "diagnosis" as a decision is a special case of this general, diagnostic-prescriptive decision problem. It is permissible to speak of a diagnosis as a decision if (1) the diagnostic cycle terminates with the identification of a single probable cause, or (2) if the prescriptive procedure considers only the most likely system state. Examples can readily be envisioned in which a prescription which considers only the most likely cause produces disasterous results. A doctor will frequently prescribe a "safe" treatment to avoid the risk of a relatively improbable disease.

Educational Prescription-Without-Diagnosis

What would be the consequences of adopting the preceding definitions of diagnosis and prescription for educational usage? It is apparent that one of the current educational applications of the diagnostic metaphor--placing the student at the outset of instruction--does not fit the definitions. There is no parallel in electronics troubleshooting to this placement problem; for the doctor-patient relationship, the area of preventive medicine seems most comparable.

There seems to be a fundamental difference between educational decisions and prescriptions in medicine or troubleshooting. Educational decisions are made in a management context, i.e., in the context of making effective use of school resources to achieve instructional goals. Prescriptions made by a doctor or a technician are usually made in an interventionist context. Decisions based on diagnosis tend to be selection decisions--the assignment of an individual to one of a set of

feasible treatments. In placement, persons are divided among two or more groups which are assigned to differential treatments (Cronbach and Gleser, 1965).

The problem of placing the student at the outset of instruction is a general assignment problem; only in very special cases can it be treated as either pure selection or placement. It may eventually be feasible to make many different types of assignment decisions simultaneously (Besel, 1971), but at present, placement and selection decisions must be made sequentially. The process of gathering information to be used in making placement decisions can be given the name, student characterization. Student characterization may involve the measurement of a wide range of psychological variables: aptitudes, learning style, traits such as intelligence, achievement indicies. These form a description of individual student strengths and individual differences rather than a summary of deficiencies and disabilities. Diagnosis is concerned with the pathological--with an answer to the question, "Why has an instructional treatment failed?" The characterization process seems sufficiently different from the diagnostic process to merit separate conceptualization and terminology.

A second case of prescription-without-diagnosis is the assignment of students to remedial instruction based solely on lower-than-desired scores on a performance measure. This is a result of treating the performance measure as a measure of a syndrome rather than as part of the diagnostic process. The performance measure thus may result in a proficiency (desired state) or non-proficiency (undesirable state) decision.

At this point, either prescription of remedial instruction or engaging in a diagnostic process to investigate underlying causes for the syndrome are feasible alternatives.

The concept of a "presymptom" (Ackoff, 1970) leads to a third instance of prescription-without-diagnosis. A presymptom is a predictor of a future symptom. If a student, during an instructional activity, gives some verbal or non-verbal indication that he has failed to grasp a concept, it may be a valid predictor of non-mastery performance on a future performance measure. At that instant, further investigation of symptoms may be neither possible nor needed. The prescription of remedial activities, review, or repetition of instruction may be feasible without intervening diagnosis. Systematic identification of valid presymptoms is a potentially fruitful area for educational research.

Educational Diagnosis-Without-Prescription

Kubie (1967) has asserted that "...any forward movement in education waits for education to develop its own corps of pathologists with courage to study its failures." He credits accountability at the autopsy table as a motivating force--resulting in rapid progress in identifying diseases and discovering cures and preventatives. It seems simplistic to assume that schools can institutionalize an educational analog of the autopsy. A school rarely knows the extent of its failures; to systematically assess the successes and failures of a school would impose a monumental task. Even if a criterion for "success" could be developed, identifying causes for failure within the complex and uncontrollable environment of a school would require an unreasonable expenditure of effort.

A more likely context for the realization of diagnosis-without-prescription is programmatic instructional development (Schutz, 1970). When an instructional program is in an early developmental stage, it is unlikely that the required entry skills are accurately known and the measures needed to characterize students for placement have not been validated or even designed. It should be expected that some students using the program will fail to achieve the desired performance standards, i.e., exhibit syndromes. But it is most unlikely that diagnostic tests and procedures which will identify the cause or learning disability will already exist or be developed in time to help the students first exhibiting the syndrome. It would, furthermore, be entirely impractical to develop remedial instructional treatments in anticipation of learning problems which rarely occur. Diagnosis must, of necessity, be done piecemeal--with whatever data are available--with no expectation of making prescriptions for the particular students involved. Within the relatively narrow context of an instructional program, detailed investigation of individual student failures is practical and profitable.

The development of decision procedures for an instructional program may be viewed as an evolutionary process. Early in development, there is likely to be predominantly diagnosis-without-prescription and prescription-without-diagnosis (prescribing remediation directly from evidence of non-mastery). As diagnostic procedures are developed and alternative instructional treatments are validated, the occurrence of diagnosis-without-prescription will diminish accompanied with an increase in diagnosis-prescription. As placement procedures--based on knowledge of

required entry skills and discovery of differential treatment/learner-characteristics relationships--are developed, the occurrence of prescriptions based on diagnosis can be reduced in frequency. However, the fact that the required entry skills are known and can be measured does not imply that they must always be assessed prior to instruction. If a deficiency in a particular entry skill is infrequent for the student population, it may prove to be cost-effective to begin instruction, and with frequent performance evaluation, diagnose those students exhibiting the syndrome characteristic of deficiency in the entry skill.

It is either naive or egotistical to assume that developmental stages can be bypassed permitting initial implementation of valid placement procedures. Reliance on placement in instructional management assumes that instruction can function effectively as an "open-loop" system. Such an approach requires the capability of assigning pupils to instructional activities with guaranteed success. Valid placement procedures require predictive capability; instability or change in student population, instructional materials or procedures tend to reduce this capability.

Diagnosis-prescription procedures are characteristic of "closed-loop" instructional systems. Proper implementation of diagnosis-prescription requires valid corrective or remedial instructional activities.

Effective placement procedures can reduce the amount of student time spent in corrective activities; retaining diagnosis-prescription procedures can soften the consequences of placement errors and permit variations or revisions of instructional materials and methods. It is

probably possible to develop an effective instructional system which has strong placement and weak diagnosis-prescription capabilities or vice-versa, but if efficient use of student time is considered, a combination of placement and diagnosis-prescription promises to be cost-effective.

Diagnosis and Prescription for Instructional Groups

Up to this point it has been implied that diagnosis-prescription refers to decisions made about individuals. The defined structure for a diagnostic problem would seem to apply to an instructional group, i.e., the group is the system for which prescriptions are made rather than the individual. While there is no apparent medical analogy, there are instructional goals for which assessment at the individual student level is either impractical or not meaningful. Group process goals, attitudes, and interests are cited as examples. It may also be impractical or counterproductive in terms of socialization goals to continually re-group students or rely on individualized modes of instruction. Group prescription of review, drill and practice with specified content, increased redundancy or altered pace of instruction could all be based on group diagnostic information. In fact, this group diagnostic information may be more reliable than comparable information concerning individual learning disabilities.

Educational Diagnosis-Prescription in Perspective

While it could well be that conceptualizations of instructional systems can avoid the diagnosis-prescription paradigm, this approach to

instructional management does appear to have cost-effective promise. Emphasis on diagnosis, with or without prescription, during program development should accelerate progress as compared to test and discard procedures. Diagnostic tests in education are relatively cheap both to construct and to administer and rarely raise the side-effect hazards of medical diagnosis. The management context of instruction which complicates the assignment-to-treatment problem has a bright side: measurement already needed for performance evaluation (quality control) and program evaluation (process control) may, if designed properly, yield diagnostic information--if so analyzed.

Treatments in the troubleshooting context can generally be classified as either replacement or repair of a malfunctioning component. Preventive maintenance is the special case of replacement in the absence of syndrome evidence. In medicine, most surgical treatments are comparable to component repair; usages of artificial limbs and organ transplants are akin to replacement of components. Medical treatments which have no troubleshooting analog include the injection of antibiotics, special diets and group psychiatric therapy. There would seem to be educational analogs, within the scope of instructional activities, to most of these troubleshooting and medical treatments.

The unrealized potential exists that instructional treatments could be generated--perhaps with computer assistance--rather than selected. An instructional program with a validated diagnosis-prescriptive capability would appear most able to capitalize on this potential. Students could be assigned to initial instruction geared to a rapid pace and low

redundancy. For those students requiring additional instruction or practice, diagnostic information could form the basis for computer generated "second instruction."

Various combinations of diagnosis-prescription, prescription-without-diagnosis and diagnosis-without-prescription provide viable alternatives to the much publicized: pretest → placement → individualized instruction → posttest paradigm. The choice is not diagnosis-prescription or pretest-placement. The challenge is to design instructional systems which exploit both paradigms.

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